US Army Service Oriented Architecture
Life Cycle Management Model

Version 0.3 - Draft

Prepared by:

Computer Sciences Corporation
3110 Fairview Park Drive
Falls Church, VA 22042

March 16, 2007

Table of Contents

Figures

Tables

Boxes

Preface

This document provides a strawman for the Army SOA Life Cycle Model. The model described is not complete but represents progress to date. Objectives for documenting the current strawman include:

- Helping clarify the methodology requirements, including the scope.
- Continuing the dialogue with the stakeholders and subject matter experts
- Understanding how the model could work within the US Army environment.

The US Army encountered difficulties when using the Defense Acquisition Framework (as described in DoD 5000) to acquire Enterprise Resource Planning (ERP) systems. The Army wants to avoid similar difficulties when acquiring Service Oriented Architecture (SOA) based systems, especially in the area where War-fighter and Business functions coincide.

An initial review of DoD 5000 and it's applicability to SOA led to the following observations:

- DoD 5000 was designed for acquiring large, tightly coupled systems (e.g., aircraft, and missile systems). These systems can take many years to build. SOA is oriented toward building smaller, loosely coupled systems, within a shorter time frame.
- In SOA the distinction between business process, application, and service is blurred. SOA systems are built so applications can be combined in different, possibly unplanned, ways to meet new threats. The business can no longer define the capabilities and requirements and pass them over to IT for development. The business must work more closely with IT throughout the development process. Does DoD 5000 allow this close collaboration?
- DoD 5000 is an acquisition methodology framework. It appears that it may not be the right framework for building Service-oriented business systems. The approach taken in this version of the document is to put DoD 5000 aside for the moment and create an engineering (versus acquisition) methodology framework to develop SOA. Then, in a later version we can revisit acquisition frameworks and ask what framework would support SOA development. The goal would be to describe what can be used instead of DoD 5000.

One suggested enhancement to DoD 5000 is Enterprise Risk Assessment Methodology (ERAM); however at the time of this writing we don't have enough information about ERAM to evaluate its applicability. According to the ERAM FAQ: "ERAM complies with the principles of DoD Directive 5000.1 and will execute the requirements created by DoD Instruction 5000.2 through a more proactive and risk-based approach." More research is needed to determine how ERAM can support SOA projects.

Introduction

The objective of this document is to provide the Army with a Life Cycle model of how to manage the SOA Life Cycle. Key SOA themes covered in the model include:

- Governance
- Adoption
- Standards
- Policy
- Service Specification
- Enabling Infrastructure

This document is structured as follows:

Chapter 1: Introduction. Introduces the objectives and provides some background.

Chapter 2: Key SOA Characteristics. Introduces key SOA characteristics.

Chapter 3: SOA Life Cycle Methodology

Section 1 – Overview. Provides a brief overview of the methodology and describes the framework used to express it.

Section 2 – Business Roadmap. The Business Roadmap component provides overall direction for SOA in any organization.

Section 3 – Service Enablement. Service Enablement provides the processes for SOA delivery.

Section 4 – Service Sustainment. Service Sustainment supports and maintains SOA not only in a steady state environment, but in an environment where an organization is on the path to SOA maturation and may be pursuing both a top down and bottom strategy as they adopt SOA.

Acronyms

References

We included some advanced topics in the Appendices:

Appendix A: Advanced SOA Features. This appendix describes the dynamic architecture and conjunctive SOA features. Dynamic architecture features permit an architecture to be established during execution. Conjunctive composition features enable conjunctive (emergent) compositions, i.e., SOAs should be designed to provide the ability to use or combine services in ways not conceived by the service's originators.

Appendix B: Advanced SOA Delivery Tactics. This appendix describes advanced aspects of SOA based delivery and its impact on the methodology.

Appendix C: SOA Security and Information Assurance. This appendix explores SOA Security and IA, specifically:

- **The Impact of SOA on Security and Assurance.** This subsection establishes a discrete basis for the differences to be accommodated in a SOA IA strategy

- **Extending the SOA UML Profile for Security.** This subsection discusses extending the SOA UML Profile overviewed in Appendix B to include security and assurance parametrics and models.

- **SOA Security and Assurance Methodology Impacts.** This subsection discusses the impact of SOA Security and Assurance on a SOA methodology. If the essence of SOA is dynamic and conjunctive composition, what are the impacts on a SOA methodology that has to assure that Security and Assurance are built in?

Key SOA Characteristics

Service Value

To ensure that the SOA Lifecycle Methodology can be applied to deliver a SOA, we must identify the key distinguishing characteristics of SOA. As shown in Figure 2-1, services are provided by collaborating components under the control of service providers to deliver value for customers and other stakeholders, including the service providers themselves. The SOA as defined in this way is applicable at all levels of the Army enterprise from the highest level organizational components to low level technology components across all mission areas.
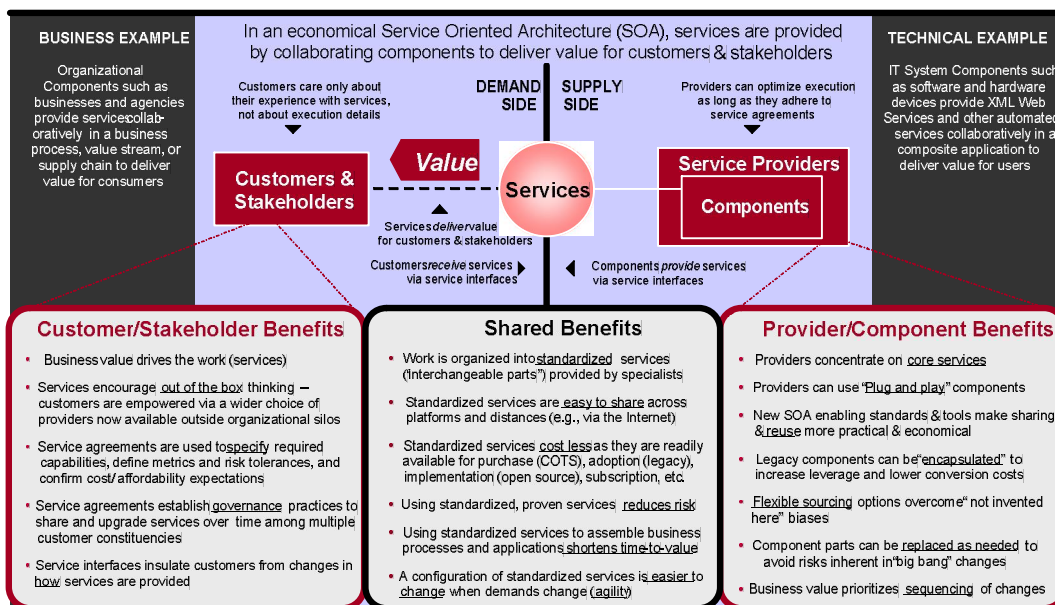
FIGURE 2-1
SOA is Oriented Around Services

This definition is congruent with the Object Management Group's (OMG's) harmonized definition of SOA, which is described in Box 2-1.

BOX 2-1. Object Management Group's (OMG's) SOA Definition

Object Management Group's (OMG's) SOA Definition

SOA is "an architectural style for a community of providers and consumers of services to achieve mutual value, that:

- Allows participants in the communities to work together with minimal co-dependence or technology dependence.
- Specifies the contracts to which organizations, people and technologies must adhere in order to participate in specific communities.
- Provides for business value and business processes to be realized by the community.
- Allows for a variety of technology to be used to facilitate interactions within the community."

The above definitions are in alignment with key Army needs:

1. Satisfy operations and all the Army communities of interest needs for information, analysis, and reporting.

2. Accommodate and acknowledge the needs of different command levels, including Future Combat System principles.

3. Dynamically respond to tactical needs, adapt rapidly to changing realities, and enable operational tempo.

4. Use an open approach that permits fresh usage of the best technologies while assuring integration and not silo-based implementations.

While service orientation is beneficial at all levels of the Army Enterprise in both business and technical architectures as stated above, experience shows that advanced benefits are achieved when technical SOA features, standards and enabling tools are employed according to best practices. Appendix A discusses some of the advanced SOA features and best practice.

Holistic View of Service Layers

One guideline to use to identify the major activities in a life cycle model is to consider the following six perspectives for each component (see Box 2-2). This provides a more holistic methodology ensuring that a key area is not forgotten. Considering a "service perspective" provides some twists that need to be considered. For one, the data/information perspective can belong both to the business-oriented view (information flows in services) and the information system view (data stores).

BOX 2-2. Holistic Business and Technology Perspectives

Holistic Business and Technology Perspectives

There are three **business-oriented perspectives** and three technology-oriented **information system perspectives:**

The business-oriented perspectives are

- The **business process** perspective, which addresses what the enterprise does, how it does it, in what sequence it does it, what rules it follows, and what type of results it obtains.
- The **organization** perspective, which addresses the people in the enterprise (their culture, capabilities, roles, team structures, and organizational units) and the (staffing, reward and recognition, education, and communication) support systems that make organizational change possible.
- The **location/facilities** domain, which addresses where the enterprise does business, both in terms of location types and specific physical facilities at a specific location.

The information system domains are

- The **application** perspective, which addresses the capabilities, structure, and user interface of software provided for the business users. Applications may be composed of services.
- The **data/information** perspective, which addresses the content, structure, relationships, and business data rules surrounding the information that the enterprise uses.
- The **technology** perspective, which addresses the hardware, system software, and communications components used to support the enterprise.

When we think about designing services in a methodology it is useful to view services as the level of abstraction that ties Business with IT resources as illustrated in Figure 2-2. If we are developing traditional (non-serviced oriented) applications, business people may provide business requirements from the business perspectives (business process, organization, location) and IT people will provide the information system requirements from the IT perspectives (application, data, technology) to support the business requirements. In that case there is a tendency for each to focus on their particular domain and not talk much to each other. As you can see from Figure 2-3 that is no longer possible when developing services – which can cross all perspectives
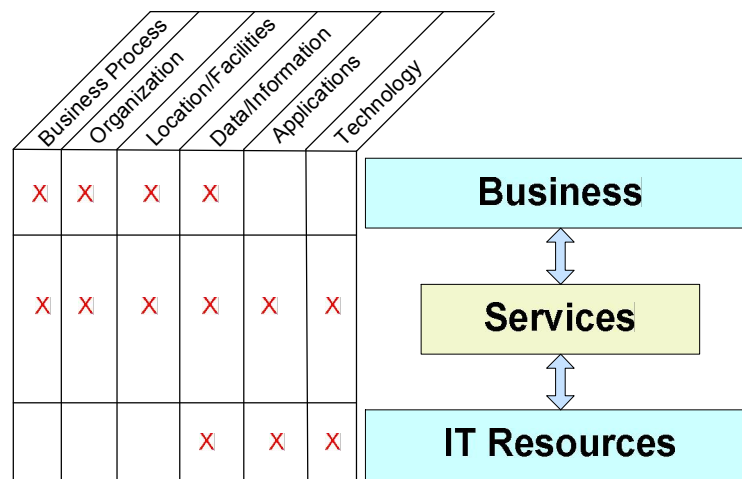
FIGURE 2-2
Business, Services, IT Resource Layers

Figure 2-3 provides an example of a possible expansion of the diagram in Figure 2.2. Although an example, this expansion will prove useful later when describing the methodology. The Business Process Services (orchestrations) in the Service Layer are automated representations of the Business Processes in the Business Layer. These services are referred to as End-to-End Processes which are composed of Reusable Process Fragments. A Business Process Service uses Composite Business Services. Composite Business Services are composed of one or more of the following services:

- **Entity Centric Services**. These are based on one or more entities, e.g., Customer. These services are context-free and are more stable and reusable than Task Centric Services.

- **Task Centric Services**. These services are based on some action or activity, e.g., Order Supplies. These services are usually context-dependent.

- **Hybrid Services**. These services are combinations of Entity and Task Centric Services.

Business Services use composite IT services. Composite IT Services are composed of the following services:

- **Application Services**. These services contain logic derived from a solution or technology platform. For example, these services could be wrappers around existing applications.

- **Data Services.** These services are the front end for data stores.

- **Utility Services.** These services offer reusable, generally solution-agnostic logic. For example, these services could be technical infrastructure support functions, e.g., messaging, transaction management.

Business Layer	Business Model		
	Business Value Chain		
	Business Goals		
	Business Processes	Organization and Location	
		Business Service Level Agreements / Shared Services	
		Events, Processes, and Information	

Service Layer (Abstraction Layer Linking Business and IT Resources)	Business Process Services (Orchestrations)	End-to-End Processes (Composite)	
		Reusable Process Fragments (Basic)	
	Business Services (Meaningful to Business and IT)	Composite Business Services	
		Basic Business Services	Entity Centric Services
			Task Centric Services
			Hybrid Services
	IT Services (Meaningful to IT Only)	Composite IT Services	
		Basic IT Services	Application Services
			Data Services
			Utility Services

IT Resource Layer	Application Resources (Components and Objects)
	Data Resources (Data Stores)
	Infrastructure Resources

FIGURE 2-3
Expanded Example of Business, Services, IT Resource Layers

SOA Life Cycle Methodology

Overview

This chapter summarizes the SOA Life Cycle methodology model, which consists of three major components as illustrated in Figure, 3-1:

- **Business Roadmap.** The Business Roadmap component provides overall direction for SOA in any organization. It establishes business objectives, creates a future service-oriented vision, and defines and prioritizes a list of business areas in which SOA work is to be done. It creates a Federated Enterprise-like Architecture which is like the city plan for SOA deployment.

- **Service Enablement**. Service Enablement provides the processes for SOA delivery.

- **Service Sustainment.** Service Sustainment supports and maintains SOA not only in a steady state environment where an organization has all the support processes and infrastructure in place and is creating services as needed, but in an environment where an organization is on the path to SOA maturation and may be pursuing both a top down and bottom strategy as they adopt SOA.
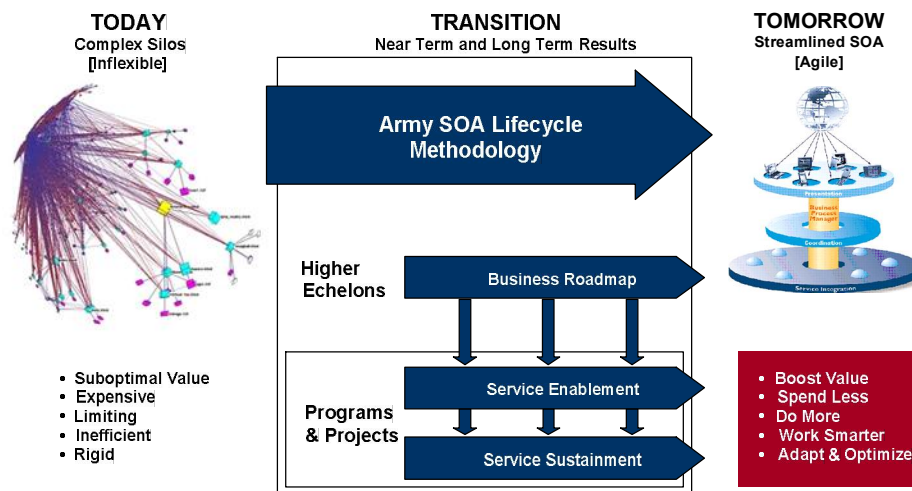
FIGURE 3-1
SOA helps Army Organizations Overcome Complexity

Each of these three methodology components is designed to be executed concurrently and continuously to realize agility, which is one of SOA's key benefits. Service Enablement and Service Sustainment methodology components are normally executed at the program and project level and apply to individual service features, components that deliver a set of services, and entire solutions comprised of

collaborating components. Similarly, the Business Roadmap methodology component, normally executed by higher echelon organizational components and communities of interest, also applies to features, components, and "solutions" at a higher level. Throughout this methodology, features, components, services, solutions and business processes at all levels must evolve continuously and concurrently, and feature changes must be delivered frequently and rapidly in order to achieve agility.

To describe the activities in the SOA model we established a more general framework for the business change and system development process. Using this framework, we can describe each of the three major components of the methodology.

Figure 3-2 illustrates the framework, which divides processes into the following two major groups. Table 3-1 provides a brief summary of each element of the framework.

- **Life Cycle** – These processes span the entire life cycle from Vision and Strategy at an enterprise-level to Operations and Support of a fielded business system.

  The Federated Vision and Strategy and Federated Enterprise Architecture groups of processes occur at the enterprise-level. They are performed for the enterprise or any major organization within the enterprise that manages a portfolio of capabilities and investments. These organizations initiate projects or programs (collections of projects).

  Development projects occur at the business area level and use the Solution Architecture, Sourcing/Development, Integration/Assembly, and Deployment life cycle processes. These projects create/update business systems. We use the term "business systems" rather that "systems" to stress the point that these systems are holistic and can cover all perspectives.

- **Management and Governance** – These include both management and governance processes.
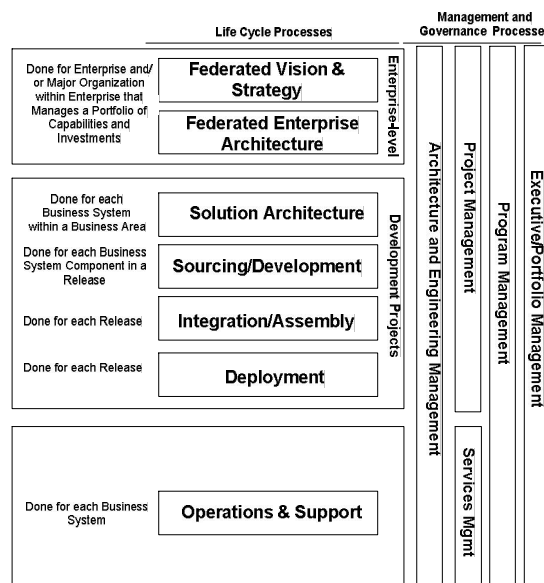
FIGURE 3-2
Methodology Framework to Support SOA

Table 3-1 describes the purpose of each framework process.

TABLE 3-1. Purpose of the Framework Processes

Framework Processes	Purpose
Federated Vision and Strategy	Establish business objectives, create future vision, and define and prioritize a list of business areas in which work is to be done
Federated Enterprise Architecture	Define Enterprise-like Architecture.
Solution Architecture	Define a Solution Architecture for each Business Area/System by defining the system requirements, designing the system including its major processes, and planning releases
Sourcing/Development	Build, transform, or acquire services and infrastructure.
Integration/Assembly	Validate entire business solution, optionally using an authentic pilot
Deployment	Deploy all aspects of business solution.
Operations and Support	Continuously operate and support the business system
Executive and Portfolio Management	Provide high-level executive and investment portfolio management
Program Management	Direct and coordinate the activities and decisions within a program, maintaining a strategic view over a set of projects, aligning and coordinating them in support of a particular business strategy.
Project Management	Identify, coordinate, and focus people and other resources to achieve project objectives within time, cost, resource, and quality constraints. Support the other management processes by providing the organizational and process infrastructure needed to make and implement effective management decisions. Project Management can include Configuration Management, Change Management, Financial Management, Knowledge Management, Planning and Measurement, Procurement Management, Quality Management, Release Management, Risk Management, and Requirements Management.
Service Management	Guide and govern service projects that occur during Operations and Support.
Architectural Engineering and Management	Direct all architectural and engineering activities, including formulating an integrated solution architecture; integrate and coordinate life-cycle activities; and ensure the deployed solution meets business objectives.

The framework illustrated in Figure 3-2 provides the context for SOA activities, work products, and techniques. It serves as a metaphor for the organization of the processes. Any metaphor can bring unwelcome entailments that can mislead. To guard against these entailments, we would like to add the following additional points:

- The framework is not meant to illustrate waterfall development. Although the goal is to synchronize them, the enterprise-level and business-level activities can and do occur at the same time in any realistic organization.

- There can be many possible life cycle paths through Solution Enablement (e.g., COTS/GOTS, rapid application development, waterfall, iterative development). As solution development proceeds a project may iterate through Solution Architecture and Sourcing/Development.

- The results of projects in Solution Enablement can inform activities in the Business Roadmap component.

SOA Life Cycle Methodology

Business Roadmap

The Business Roadmap component provides overall direction for SOA in any organization. It establishes business objectives, creates a future service-oriented vision, and defines and prioritizes a list of business areas in which SOA work is to be done. It creates a Federated Enterprise-like Architecture which is like the city plan for SOA deployment.

Business Roadmap processes are done at the enterprise-level for the enterprise or a major organization within the enterprise that manages a portfolio of capabilities and investments.
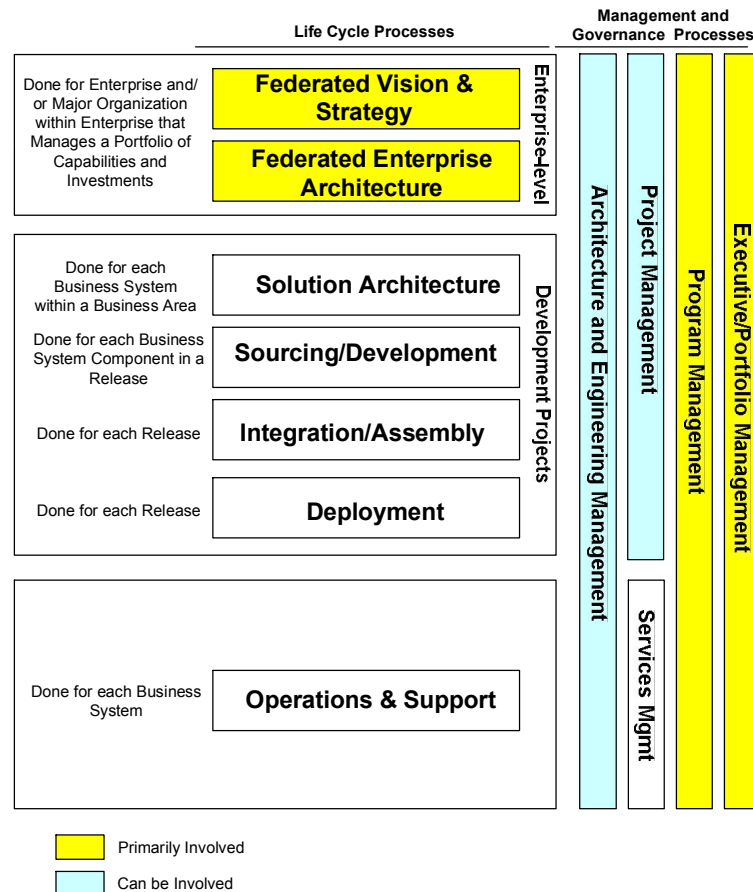
FIGURE 3-3
Business Roadmap Processes

The following figure lists the major activities within the Business Roadmap component. Multiple activities with no arrows between them in a box can be done

concurrently (e.g., "Survey Business Domains, Systems and Services" and "Develop Service-Oriented Vision for Enterprise).

Federated Vision & Strategy

- Evaluate the Need for SOA
- Survey Present Business Domains, Systems and Services
- Develop Service-Oriented Vision for Enterprise
- Define SOA Adoption Strategy
- Develop Service-Oriented Policy Guidance

Executive/Portfolio Management

- Manage Investment Portfolio

Federated Enterprise Architecture

- Define Service-Oriented Principles
- Identify SOA-Related Standards
- Identify Service-Oriented Target State

Program Management

- Develop SOA Governance and Management Strategy

FIGURE 3-4
Major SOA Business Roadmap Activities

The following describes the major activities within the Business Roadmap component.

Federated Vision and Strategy

1.   Evaluate the Need for SOA

Inputs	Outputs
• High-level business needs • Business issues • Existing strategy and vision documents, if available • Capability delivery documents, if available • Business capability descriptions, including stories (day in the life of) processes, goals and functions needed • EA principles, if available • Directives and mandates, e.g. FEA compliance	• SOA Needs Analysis

This activity evaluates or confirms the need for SOA and determines the important business drivers are that will affect architectural decisions. This is important for validation and for deciding on tradeoffs. This activity is usually done concurrently with the Survey Business Domains, Systems and Services activity. It addresses the following areas:

- **SOA Appropriateness.** The main question to ask when evaluating the need for SOA is "What are the characteristics of the problem domain that necessitates the use of SOA features?

  - **Situational Processes.** Do you want to enable dynamic and situational processes? Dynamic processes mean that the selection of the specific individual services and components are based upon the specific situation encountered during execution.

  - **Situational Integration (Orchestration).** Do you need to combine components/services/systems into differing collaborations to satisfy specific needs? This differs from Situational Processes, in which time is explicit, i.e., the processes can change based on initiating events. In Situational Integration the type of service depends on the context and situation (e.g., the type of weather forecasting service needed depends on the situation).

  - **Interoperability.** Do you need interoperability between autonomous and concurrently developed and deployed components, systems, and services? The complexity of existing point to point interfaces may become too difficult to manage.

  - **Business Collaboration.** Do need improved collaboration between sister services?

  - **Legacy Integration and Service Enablement.** Do you wish to reuse your legacy assets in a more dynamic and agile way?

  - **Best of Breed Assembly.** For example, typical solutions make comprises between functionality and use of a single product. Do we choose SAP or a collection of best of breed services that can integrate together to provide a better business fit?

- **Desire for Smaller Acquisitions.** The design principles of SOA enable autonomous deployment. Therefore, you can plan smaller and more numerous deployments, reduce the risk scope down to individual services, and allocate money in small chunks not big chunks.

- **SOA Features and Benefit.** What are the features and benefits of SOA? Although the features and benefits of SOA are many, five distinct overarching features and their associated benefits can be identified as shown in Figure 3-5 below. Note as above, these features and benefits are applicable at all levels of the Army Enterprise across both business and technical aspects of enterprise, solution, and individual component architectures.

- **SOA Importance.** How important is SOA to this enterprise? Where can it be applied?

- **Case Against SOA.** Understand when not to implement SOA. For example, SOA might not be appropriate when true-real time performance is critical, requiring nano-second responses (e.g., telephone switching).

- **Business Issues.** What are the issues driving us to consider SOA?

- **Business Needs.** Can SOA help us better address our burning business needs?

Features	Benefits to Clients
SERVICE RESPONSIBILITIES ARE CLEARLY DEFINED Work is organized into well-defined services that deliver clear value for customers & stakeholders, based on a mutual agreement on customer vs. provider responsibilities.	**CLIENTS BOOST VALUE THAT THEIR SERVICES DELIVER** Clients incorporate best practices used by commercial service providers into planning, enablement and operations. Clients focus on their customer, concentrate on their core services, and organize around these services.
MODULAR SERVICES ARE USED AS BUILDING BLOCKS Business processes, applications, and other complex services are assembled ("composed") using simpler, modular services as building blocks ("orchestration").	**CLIENTS SPEND LESS TIME AND MONEY AND ARE MORE AGILE** Clients save time because they don't have to build all needed capabilities from scratch. Clients save money because commodity services are usually cheaper than custom services, and because proven services reduce risk.
SOA STANDARDS AND TOOLS ACT AS THE GLUE New Internet standards such as XML and Web Services, new SOA enabling infrastructure, and other tools are used to provide a rich, scalable, and secure set of services.	**CLIENTS CAN DO MORE FOR THEIR CUSTOMERS** Services are easier to share across platforms and distances. As a result, clients can serve more customers, get more out of legacy systems, and choose from a wider selection of services to do more for their customers.
SERVICES ARE SHARED ACROSS ORGANIZATIONS Services are distributed among providers who specialize in their core competency (Division of Labor), and providers of like services are consolidated.	**CLIENTS WORK SMARTER WITH GREATER EFFICIENCY** Services are provided by the most effective providers, which yields the highest quality results. Also, services of like kind are provided by a limited set of providers, reducing waste and increasing efficiency.
SERVICES CAN EVOLVE INDEPENDENTLY Services are provided according to agreements that separate customer and provider concerns. Providers are free to make changes as long as they meet the terms of their agreements.	**CLIENTS CAN ADAPT BY MAKING CHANGES INCREMENTALLY** Clients can reduce the impacts of transformational changes such as re-engineering and automation by insulating customers via interfaces and using agile methods to deliver incremental features on a continuous basis.

FIGURE 3-5
Overarching SOA Features and Benefits

This activity creates a SOA Needs Analysis where SOA features and benefits are aligned with business needs and issues. This work product can be updated throughout the Business Roadmap component.

2. Survey Present Business Domains, Systems and Services

Inputs	Outputs
• Documentation of current business domains, systems and services • Business Needs • Community of Interest Expectations • Service-oriented Vision	• Asset Inventory • Business capability descriptions, including stories (day in the life of) processes, goals and functions needed

This activity is done concurrently with the Develop Service-Oriented Vision for Enterprise.

In each business domain covered by the federated enterprise, assets need to surveyed and catalogued. Here the assets are captured at a high-level. They are captured more in-depth, as needed, during the Service Enablement component. Look at only at assets that you could incorporate into a SOA environment consistent with the SOA vision.

An asset inventory serves many purposes. One is to support the service sourcing and usage strategy, which is about where to get the service and to whom to offer the service. Assessing the business value of each asset helps determine, for example, if it should continued to be maintained, needs to replaced or eliminated, or can be leveraged to support new services.

The assets cover all resources, e.g., business units, applications, systems, and services. It can cover current and future assets and includes a description on how will meets current and anticipated needs.

3. Develop Service-Oriented Vision

Inputs	Outputs
• SOA Needs Analysis • Business capability descriptions • Asset Inventory	• Service-Oriented Vision

The objective is to express the entire or a portion of the Federated Enterprise's vision and strategy as service-oriented and establish priorities. The vision includes:

- Identification of all stakeholders and their strategies
- Identification of the scenarios sponsored by those stakeholders
- For each scenario establish the high-level capabilities required including necessary processes, required functions and measurable goals.

This activity establishes the high-level demand for SOA as illustrated in the left side of the following figure.
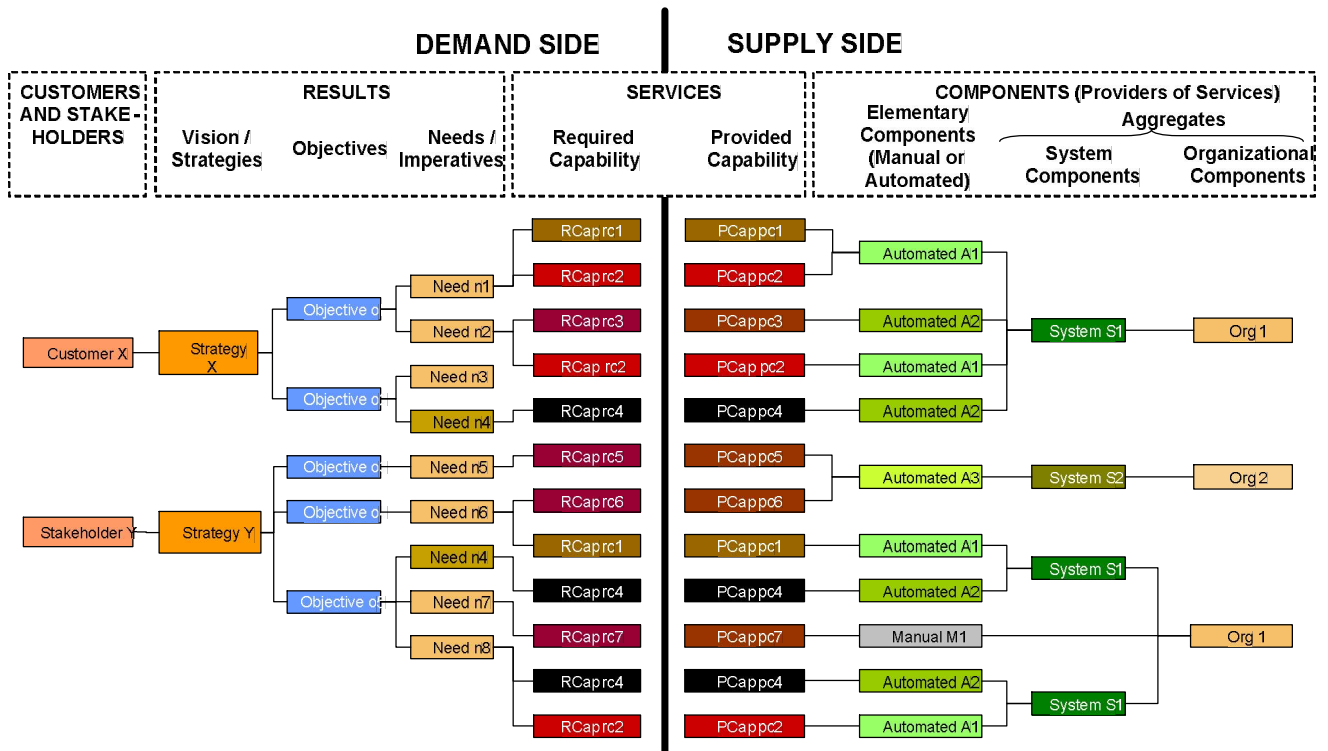
FIGURE 3-6
Vision and Strategy Establishes the Basis for Portfolio Investment Decisions

Figure 3-6 is also useful in illustrating the thread of SOA development from customers and stakeholders with a vision to providers that provide services to realize that vision.

4.   Define a SOA Adoption Strategy

Inputs	Outputs
• Stakeholders • Information about target organizations	• SOA Readiness Assessment • SOA Adoption Strategy • Identification of early adopters

This activity evaluates the organizations readiness for SOA and deals with the question how to introduce SOA into organization. This is one level above the "as is" to "to be" transformation and deals with organizational change issues associated with the adoption of SOA. It creates a SOA Readiness Assessment and SOA Adoption Strategy based on the assessment. Box 3-1 provides some insight in what people to approach when introducing SOA into an organization.

BOX 3-1. Start with the Right People

Start with the Right People

In his book, *Diffusion of Innovations*, Everett Rodgers, suggests five adopter categories for any innovation, such as SOA: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards.

- The "Innovators" take up a small percentage of the population and typically jump from one innovation to another so they may not be the best "champions" because they may not have the necessary influence with their peers.
- The "Early Adopters" don't need a formal business case and can see quickly how the innovation will pay off. They are ready to start using it.
- The "Early Majority" needs a business case and needs to see that people are using the innovation.
- The "Late Majority" will use the innovation if it is well-packaged and everyone else is doing it.
- The "Laggards" will never adopt the innovation.

One strategy is to focus your initial messages to the Early Adopters and build enough momentum to gain the attention of the Early Majority with metrics pulled from the Early Adopter SOA projects. Select SOA champions from the Early Adopter group.

In the organization there are numerous stakeholders: project managers, architects, etc. So it might be worth considering how each of the groups may need to be approached and influenced. For example the typical situation may be an early adopter architect with a late majority project manager.

The SOA Adoption Strategy identifies key characteristics of the approach, including deciding how much to invest and where. It also addresses an appropriate balance between top-down and bottom-up approaches (see Box 3-2). It will also identify SOA adoption barriers and the corresponding tactics to address these barriers.

BOX 3-2. Top-down to Bottom-up Approach?

Top-down to Bottom-up Approach?

A pure top-down or a pure bottom up approach for enabling a sustainable SOA delivery process will not work. Service-oriented programs and projects that are underway cannot be easily changed. It is risky to assume that delivery of critical functions can wait for alignment of the Enterprise level strategy, business model, and delivery objectives.

But allowing programs and projects to be established independent of the assets that they deliver is equally risky. Without any integrating force to assure horizontal integration in the context of alignment to enterprise vision will most likely result in overlap of function, inconsistency, lack of timeliness of information delivered, less than efficient usage of scarce resources, and a sustained inability to respond quickly to new threats and opportunities.
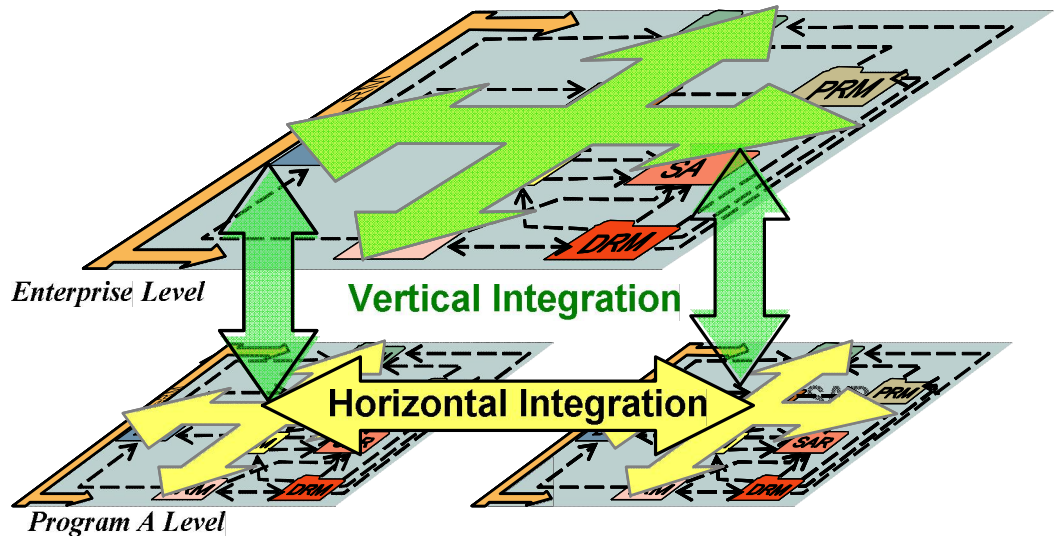
FIGURE 3-7
Horizontal versus Vertical Integration

Experience shows that widespread implementation of key SOA features and realization of their associated benefits faces significant challenges within a large enterprise. Any implementation of SOA needs not only to enable these key SOA features, but must also enable tactics that experience shows to have been successfully used to implement SOA within large enterprises, as shown in Figure 3-8.

SOA Feature	Benefit for Clients	Adoption Barrier	Adoption Tactic
SERVICE AGREEMENTS Work is organized into well defined services with clear responsibilities	**BOOST VALUE** Concentrate on and organize around core services	**PROGRAM ORIENTATION** • Orgs manage programs - not used to services	**EDUCATION / OUTREACH** • Focus on managing services • Avoid techno jargon
MODULAR SERVICES Use as building blocks to assemble business processes and applications	**SPEND LESS** Modular services save time & money; proven ones lower risk	**SERVICE SELECTION** • Choosing the right module • What's needed vs. available	**SERVICE CATALOGS** • Easy to reuse (already exist) • Easy to buy (COTS, Open Src)
SOA STANDARDS & TOOLS XML, Web Services, SOA enabling tools, etc. act as the glue	**DO MORE** Use and provide a richer set of secure, scalable services	**ADDITIONAL COSTS** • Standards enforcement • Tools investment	**PILOT CUSTOMERS** • Willing partners and sponsors • Clear business case
SERVICE SHARING & REUSE Assign services to specialists and consolidate providers of like services	**WORK SMARTER** Minimize waste, increase efficiency, leverage legacy	**CULTURAL RESISTANCE** • Loss of control (risk) • Low levels of trust	**BALANCED GOVERNANCE** • Increase transparency • Incentivize sharing
SERVICE INDEPENDENCE Services evolve independently as long as they adhere to the agreement	**ADAPT AND OPTIMIZE** Lower the impact of trans formational changes	**"IN-FLIGHT" CHANGES** • Change = Risk • Can't stop to make change	**INCREMENTAL CHANGE** • Interfaces insulate customers • Agile change management

FIGURE 3-8
SOA Adoption Barriers and Tactics

5.   Develop Service-oriented Policy Guidance

Inputs	Outputs
• Existing policies • Service-oriented Vision	• Service-oriented Policies • Policy Implementation Action Plan

This activity develops or updates the policies need to realize the SOA vision and associated strategies. It also creates an action plan to implement the strategies and an associated budget that implements the policies and prepares for SOA-based work across the complete life cycle.

This activity starts the process of specifying policies. This process can continue throughout the life cycle as an organization develops a service-oriented vision and strategy, SOA standards, and maturity in SOA development. Business areas may develop their own policies based on their own needs.

Federated Enterprise Architecture

A Federated Enterprise Architecture defines the future or target state of an enterprise or of a major organization within the enterprise to more successfully accomplish its mission. Successful enterprise architecture addresses all business areas that constitute the enterprise or major organization. The architecture aligns all six perspectives: business process/service, organization, location/facilities, data/information, application, and technology. Many service-oriented and SOA activities occur at an enterprise-architecture level.

BOX 3-3. City Planning Analogy

City Planning Analogy
A popular analogy is comparing enterprise architecture to city planning. City planning: • Identifies residential areas, shopping areas, industrial areas, recreational areas, and their relationship • Plans for common facilities such as parks and sports complexes • Provides for infrastructure planning such as roads, utilities, and transportation • Provides zoning regulations and building codes for the development of structures and facilities. Similarly, an enterprise architecture guides the development and growth of the enterprise by providing both structure and standards.

6.   Define Service-oriented Principles

Inputs	**Outputs**
• Service-oriented Vision • Standardized set of SOA features (see Appendix A)	• Service-oriented Principles

There are three parts to the defining principles:

- **Applicable Features.** Define the features that apply to each segment of the Federated Enterprise. Candidate features are listed in Appendix A. Table 3-2 provides an example using the late binding feature. For example late binding of services is usually more important to line operations then the standardized practices of back office business operations.

- **Measurable Expectations.** Define specific measurable expectations for each of the SOA features. For the Late Binding feature a typical measure is McCabe Cyclomatic Complexity. There would be different value ranges of this measure for each of the segments. This is an objective measure of loose coupling. This can tell whether you have been successful at implementing loose coupling in each of the business segments.

- **Guidance.** Guidance on the system architecture and delivery requirements so that the features are successfully delivered.

TABLE 3-2. Late Binding Feature Applicability to Different Business Services

Feature	Business Segment 1	Business Segment 2	Business Segment 2
Late Binding	Register formal service interfaces in a run-time repository	Only register the service interfaces of adaptor and façade services to other business segments (or outside entities) in a run-time repository.	Register the services interfaces of all adaptor, façade, and work flow services in a run-time repository.

7.   Identify SOA-Related Standards

Inputs	Outputs
• Service-oriented Vision	• Identified SOA Standards, Guidelines and Conventions

Identify SOA Standards and Guidelines, including SOA patterns and XML standards. There will be SOA policies that direct organizations to implement the standards.

8.   Identify the Service-Oriented Target State

Inputs	Outputs

• Service-oriented Vision
• Asset Inventory
• Identified SOA Standards, Guidelines and Conventions
• SOA Adoption Plan
	• Service-Oriented Target State
	  – Business Architecture
	  – Information System Service Requirements
	  – Information System Service Architecture
	• Identified SOA Standards, Guidelines and Conventions (updated)
	• SOA Integration Strategy
	• Near Term SOA Projects (identified)

8.1. Define Business Architecture

The following three steps would be done concurrently.

1. IDENTIFY FUTURE HIGH-LEVEL BUSINESS SERVICES/PROCESSES

This step identifies:

- Key customers and stakeholders and their business needs.
- Services/processes that satisfy their business needs. This may include casting or reframing existing processes into a service point of view. Business processes orchestrate the services.
- Major business entities can also help identify services.
- The processes are identified down to the reusable process fragment level to identify planned reuse at the enterprise level -- decomposition to lower levels would be done by projects for business areas during Service Enablement.
- Organizations, IT systems, and facilities that provide the services.

The following figure illustrates some of this analysis. It illustrates how SOA helps organizations at all echelons boost value by aligning the services in the Value Stream with the strategic agenda
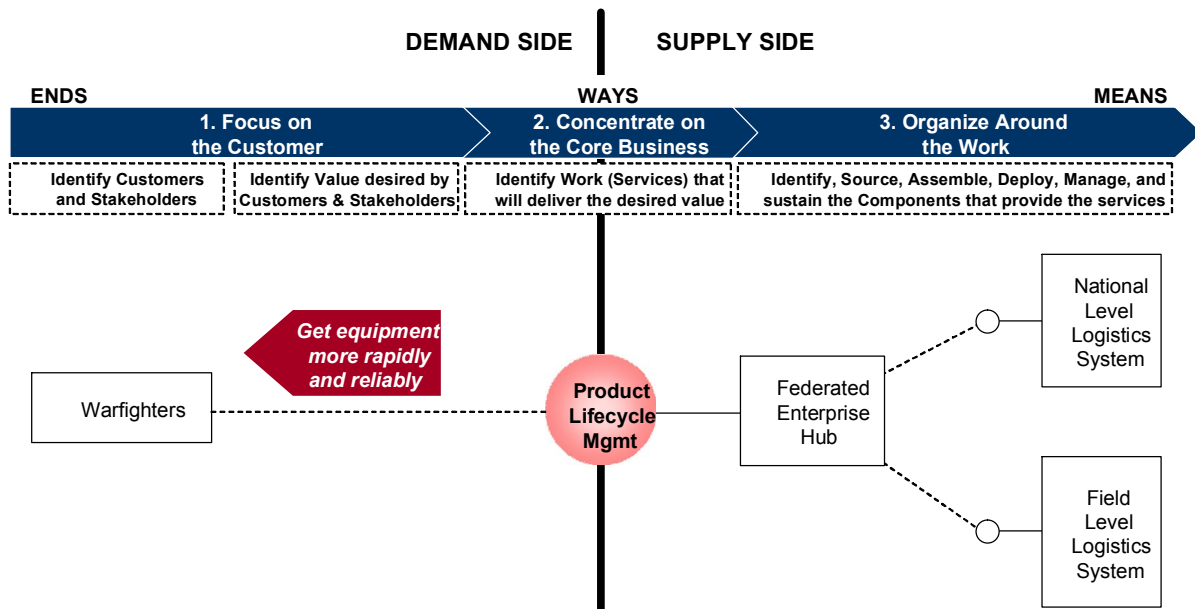
FIGURE 3-9
SOA Helps Organizations Boost Value

2. IDENTIFY HIGH-LEVEL COMMON ENABLING BUSINESS SERVICES

This step looks across the business processes and services for common fragments. It considers services at a high-level, e.g., collaboration instead of e-mail.
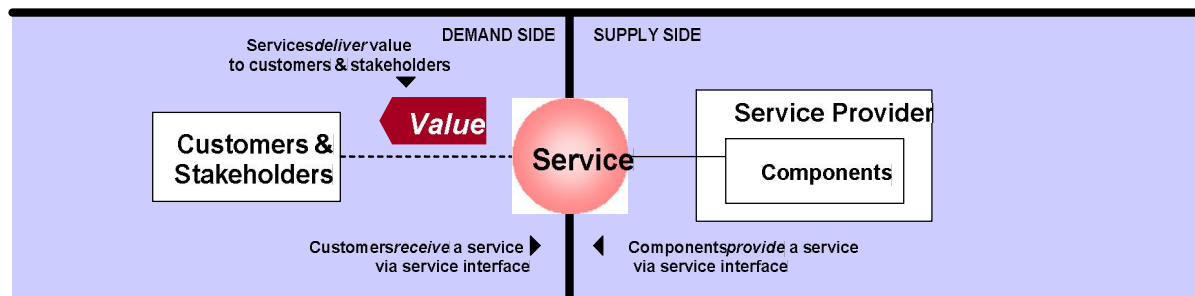
FIGURE 3-10
Demand and Supply Sides

3. IDENTIFY SOA OPPORTUNITIES

This step looks at business priorities (e.g., need for agility, need to integrate systems), business services, and processes and examines which parts of the enterprise have situations that could be benefited by SOA. For example it looks for opportunities to:

- Consolidate redundancy

- Boost value of existing services
- Lower costs of existing services.

8.2. Define Information System Service Requirements

These are high-level requirements at the enterprise level. They include:
- SOA Functional Requirements
- SOA Infrastructure Requirements
- SOA Security and Information Assurance Requirements
- SOA System Management Requirements
- SOA Information/Data Requirements
- SOA Performance Requirements.

8.3. Define Information System Service Architecture

Define an information system service architecture to support the business architecture (i.e., business requirements) and the information system service requirements. This includes:
- **Defining a Federated Information Model**
- **Identifying High-level Automated Services**
- **Defining Information System SOA Reference Models**
- **Defining Service-oriented Application Architecture**
- **Defining Service-oriented Technology Infrastructure**. The infrastructure could include the enterprise service bus, messaging middle ware, technical services to support transaction management (compensation), message protocol conversion, message content format conversion, and security. You would define the services required and the approach to fulfilling them in the Federated Enterprise Architecture (EA) and then (separate from EA) run an infrastructure project to realize those capabilities. This needs to be planned at enterprise-level because it is the glue that enables enterprise SOA
- **Defining SOA Information Assurance Architecture.** See Appendix C for a discussion of SOA and information assurance.

8.4. Plan Transition

Plan transition to the service-oriented target state:
- **Define Near-term SOA projects.** Define initial projects. These should include projects that demonstrate feasibility and projects that would be quick wins.
- **Define SOA Integration Strategy.** For each type of problem that SOA will be solving what will be the general approach. For example, integration strategies could include how to move from legacy systems to SOA. The integration strategy is more segmented than the adoption strategy and more of the technical concept of how you expect to achieve integration.

.

9.   Develop SOA Governance & Management Strategy

Inputs	Outputs
• Service-oriented Vision • SOA Policies	• SOA Governance and Management Strategy – Identified SOA governance bodies – SOA Governance Model • SOA Policies (updated)

This activity develops a strategy for governing and managing SOA. The strategy could be a hybrid one mixing a top-down deliberate strategy and bottom-up emergent strategy.

This activity defines what governance means for the enterprise or organization and establishes governance mechanisms. Governance is extremely important, but is also deceptively challenging. You need just the right amount of governance – too much raises barriers and too little invites chaos. Either can cause SOA to fail.

SOA initiatives can impact traditional IT governance mechanisms.

Figure 3-11 illustrates the major question areas SOA governance needs to address. SOA Governance Bodies, a SOA Governance Model, and a SOA Life Cycle Model help address these questions:

FIGURE 3-11
SOA Governance

- **Who – SOA Governance Bodies.** SOA governance bodies that understand the business goals and SOA architecture and can sensibly resolve misalignments. These are the people that are responsible for the "What" and drive the "How / When". They address common questions such as:
  - Who "owns" the SOA services? (functional, technical, operational)
  - Who "owns" the SOA services development standards and processes?
  - Who "owns" the SOA infrastructure?

- Who can use the SOA services?
- Who will build the SOA services?
- Who can change or fix the SOA services?
- Who will pay for the SOA services' development & support?
- Who will pay for the SOA service infrastructure?

- **What –- SOA Governance Model.** The SOA Governance Model defines where you are trying to get to and measures project architectures and designs against these requirements. It addresses common questions such as:
  - What functionality is provided by the SOA architecture & infrastructure?
  - What enterprise architectural and/or regulatory standards must be supported by the SOA infrastructure?
  - What makes a good (well-designed, well-built) service?
  - What quality of service is required?
  - What services have been developed or will be developed that would be good candidates to become common services?
  - What SOA policies need to be established?

- **How / When – The SOA Life Cycle Model.** The lifecycle process includes review points where the governance process is engaged. This answers the requirements established in the "What". It addresses common questions such as:
  - How are interdependencies managed?
  - How will SOA services or standards be published?
  - How can we encourage use of SOA across the organization?
  - How will we enforce that SOA is being used properly?
  - How are SOA services being leveraged within an application?
  - How do we measure SOA services usage?
  - How will change requests be handled?
  - How will services be exposed to stakeholders?
  - How will we know that services are being used properly?
  - How will we measure and report on Service Level Agreements (SLAs)?
  - How will we measure and report on SOA program adoption?
  - How will we resolve issues between program participants?

Executive/Portfolio Management

10.   Manage Investment Portfolio

Inputs	Outputs
• Investment Portfolio	• Investment Portfolio (updated)

Each organization has its own way of managing portfolio. We make this activity explicit because of its importance to SOA.

SOA Life Cycle Methodology

Service Enablement

Service Enablement provides the processes for SOA delivery. It is done for each business system within a business area and is managed as a program with many projects or as one project. It relies on Business Roadmap artifacts to provide high-level direction. Service Enablement projects may also provide results that inform and change some of these enterprise-level artifacts.
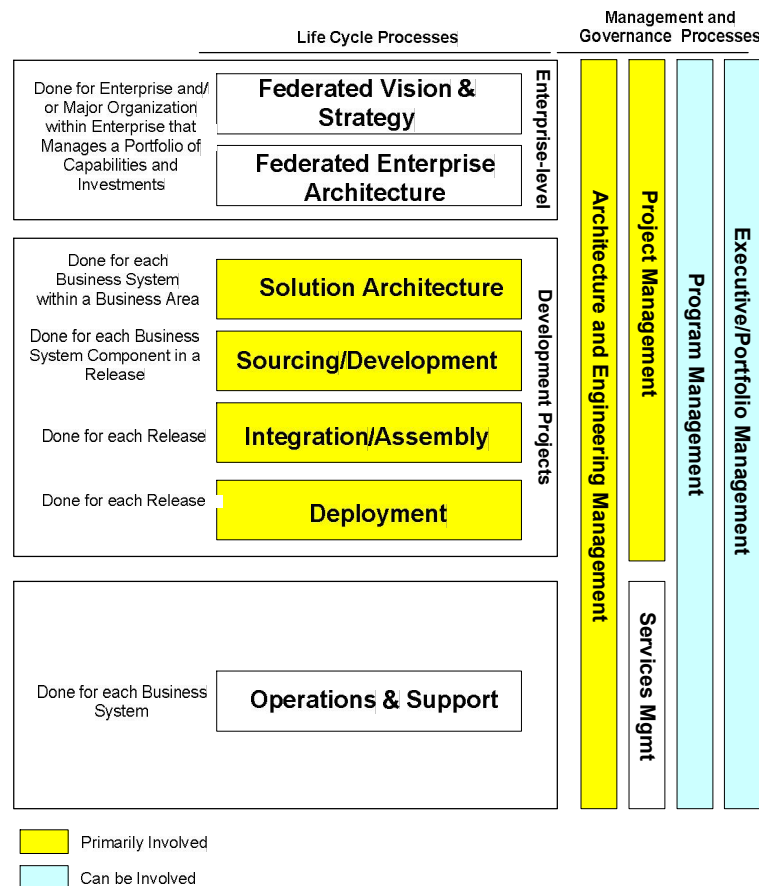
FIGURE 3-12
Service Enablement Processes

The following figure lists of the major activities within the Service Enablement component.

Solution Architecture

- Evaluate/Confirm the Need for SOA
- Survey Present Business, Systems and Reusable Assets

↓

- Develop Service-Oriented Vision for Business Area

↓

- Develop Business Service Architecture

↓

- Define Information System Service Requirements
- Define Information System Service Architecture

Sourcing/Development

- Evaluate and Select Services

↓

- Develop Services
- Develop/Update Service Infrastructure

Architecture and Engineering Management

- Plan for SOA Adoption
- Define SOA Design Guidance
- Define SOA Verification & Validation Approach
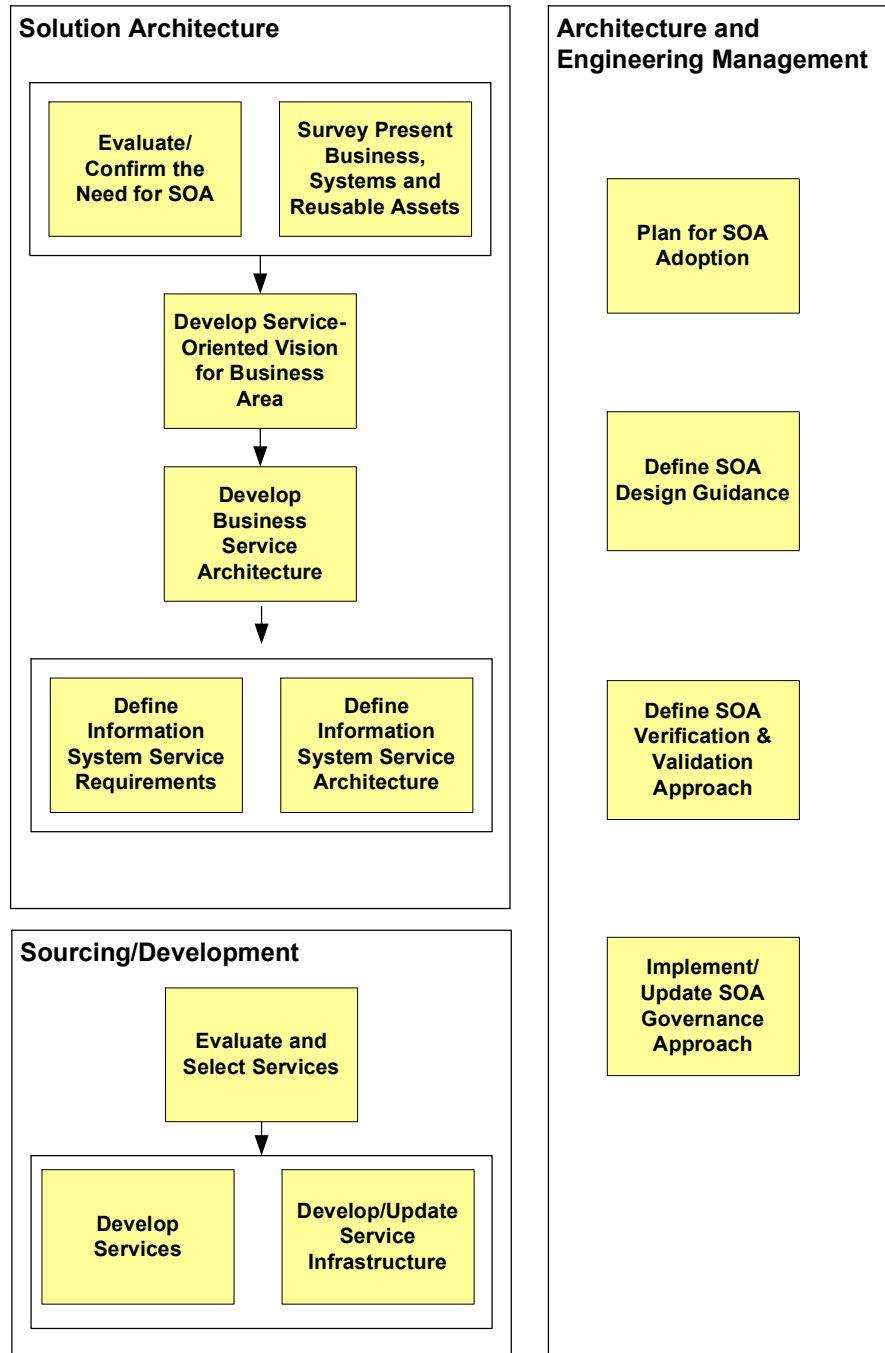- Implement/Update SOA Governance Approach

FIGURE 3-13
Service Enablement Major Activities

The following describes the major activities within the Service Enablement component.

Solution Architecture

1.   Evaluate/Confirm the Need for SOA

Inputs	Outputs
• SOA Readiness Assessment (Enterprise-level) • SOA Implementation Strategy (Enterprise-Level)	• Confirmed need for SOA

Here you evaluate or confirm the need for SOA in your business area. This activity is done concurrently with the "Survey Present Business, Systems, and Reusable Assets" activity.

2.   Survey Present Business, Systems and Reusable Assets

Inputs	Outputs
• Asset Inventory (Federated Enterprise level)	• Asset Inventory (Business Area level)

Review the Federated Enterprise Asset Inventories. These inventories were created at a high level. Select relevant assets that are applicable to your business area and add additional detail as needed.

3.   Develop Service-Oriented Vision Business Area

Inputs	Outputs
• Asset Inventories • Service-Oriented Vision (Federated Enterprise level) • Service-oriented Policies	• Service-Oriented Vision (Business Area Level)

Develop a service-oriented vision for the business area. This is consistent with the enterprise-level vision but would have more detail for your business area.

4.   Develop Business Service Architecture

Inputs	Outputs
• Service-oriented Vision • Asset Inventories • Service-oriented Target State	• Business Service Architecture

This activity identifies and defines the business services as illustrated in the shaded portion of Figure 3-14. The steps in the Business Roadmap activity "Identify the Service-Oriented Target State" also apply here, except at a lower level (i.e., for a business system). At the business area level you would deal with the services at a lower level than those considered in Business Enablement, e.g., e-mail instead of collaboration.

Service Layer (Abstraction Layer Linking Business and IT Resources)	Business Process Services (Orchestrations)	End-to-End Processes (Composite)	
		Reusable Process Fragments (Basic)	
	Business Services (Meaningful to Business and IT)	Composite Business Services	
		Basic Business Services	Entity Centric Services
			Task Centric Services
			Hybrid Services
	IT Services (Meaningful to IT Only)	Composite IT Services	
		Basic IT Services	Application Services
			Data Services
			Utility Services

FIGURE 3-14
Business Process and Business Services

Major steps include:
- Confirm SOA opportunities identified at the enterprise-level. Examining the business area's business processes, business entities, and services may lead to additional SOA opportunities.
- Define business entities
- Identify Candidate Business Services from processes and/or entities. Keep in mind the distinction between business processes and services as described in Box 3-4.
- Identify Common Enabling Business Services

BOX 3-4. Business Process or Service?

Business Process or Service?

Some people say "business process = service." Actually, the two are separate concepts, with some interrelationship.

If a service is a behavior performed by a structure (actor) to achieve some desired effect (state) for a customer (another structure / actor), then business process fails that test. Consider a process that involves two different entities (e.g., a company and its customer). The process is a collaboration of the two entities. Each entity has its own view of that process and treats the other as a black box. Each entity can implement a process service to run their side of the process and to keep tabs on the external state of the other's participation in the process (e.g., has the customer accepted the bid yet?). So the business process is not performed in this case by one actor for benefit of another, but by two actors for mutual benefit. Taking a service view of that process requires viewing the process from the viewpoint of just one of the participants. So I think that this indicates that there are processes that are larger than a single process service and are performed by more than one actor, and therefore not all processes are services.

Conversely, we assume that a business process is a stateful context-aware orchestration of events (a path through a series of activity states) -- in our case an orchestration of services. However, we recognize that the ideal nature of the underlying services is that they be stateless and context-neutral. Therefore there are services that are not processes.

Combining these two arguments, we can draw a meaningful distinction between the concepts of process and service. Like a Venn diagram, there is some overlap of the two concepts. A process can be represented by one or more process services, and some services are process orchestrations. However, there is also a distinction (not all services are processes, and not all processes can be represented by a single service), so the two are not identical.

If the project is delivering services, it will need to elicit information such as the information in Table 3-3 from Customers/Stakeholders on the Demand side and Service Providers on the Supply Side (see Figure 3-9) to further define the service.

TABLE 3-3. Service Information

Concerns for Both Customer/Stakeholder and Provider	Concerns Of The Provider Only
What is the Service? (Service Name and Description)	Who are the Customers and Other Stakeholders?
What value does the service deliver?	What components are used to provide the service?
What work gets done? (Functionality)	What data is stored within the components?
What is acceptable performance? (e.g., SLAs)	How do the components work together? (orchestration)
How do you use the service? (Interface)	How the components are sourced? (e.g. built, purchased, leased, subscribed to, etc.)
What are the Inputs and Outputs?	How are the components assembled?
What does the subscription cost and how is payment made?	How are the components deployed? (sequencing, etc.)
What other subscription agreements apply? (separation, other terms)	How is the service operated?
How do I get problems resolved?	How is the service financed? (Central vs. Customer Funded)
How do I request and track changes?	What optimizations are planned?
What improvements are planned?	

5. Define Information System Service Requirements

Inputs	Outputs
• Business Service Architecture • Information System Service Requirements (Federated Enterprise-level)	• Information System Service Requirements (Business Area Level)

Define the following SOA information system requirements:

- SOA Functional Requirements
- SOA Infrastructure Requirements
- SOA Security and Information Assurance Requirements
- SOA System Management Requirements
- SOA Information/Data Requirements
- SOA Performance Requirements

6. Define Information System Service Architecture

Inputs	Outputs
• Information System Service Requirements • Business Service Architecture	• Information System Service Architecture • Business Service Architecture (updated)

This activity updates the Business Services and defines IT Services as illustrated by the shaded portions in the following figure:

FIGURE 3-15
Business and IT Services

This activity also:

- Updates the Information Model
- Identifies Automated Services
- Selects/Confirms Information System Reference Model
- Defines Service-oriented Application Architecture
- Defines SOA Information Assurance Architecture.

Sourcing/Development

7. Evaluate and Select Services

Inputs	Outputs
• Asset Inventories • Business Service Architecture • Information System Service Requirements • Information System Service Architecture • Service registries • Service Catalogs • Taxonomies	• Sourcing Analysis Results – Selected reusable services

Evaluate and select services using the following major steps:

- **Review Service Catalogs and Taxonomies.** Review existing service catalogs for reusable services to meet the business needs. Using industry analyst taxonomies may help define the types of services you need (e.g., Gartner). For example, consider:
  - Enterprise Service Registry
  - Internet-based Registry (e.g., Google earth)
- **Perform a Gap-fit Analysis**
- **Perform Source-Make Decisions.** Based on the review of service registries and the gap-fit analysis you might decide among the following options for each needed service:
  - Subscribe to an existing one. You might also decide to reuse the service without change or extend it by adding functionality.
  - Buy (could be open source or COTS) the service.
  - Build the service.
  - Adopt what you own (e.g., GOTS).

8. Develop Services

Inputs	Outputs
• Business Service Architecture • Information System Service Requirements • Information System Service Architecture	• Service Registry • Services – Service Specification

Develop the services.

9. Develop/Update Service Infrastructure

Inputs	Outputs
• Information System Service Requirements • Information System Service Architecture	• Service Infrastructure (logical and physical)

Develop or update the service infrastructure.

Architecture and Engineering Management

10. Plan for SOA Adoption

Inputs	Outputs
• SOA Adoption Strategy	• SOA Adoption Plan

Create a plan to SOA adopt SOA in the organization.

11. Define SOA Design Guidance

Inputs	Outputs
• Information System Service Architecture • Service-oriented Principles • SOA Standards, Guidelines and Conventions	• SOA Design Guidance

Define SOA design guidance. See Appendix A for a description of how SOA features can be enabled.

12. Define SOA Verification & Validation Approach

Inputs	Outputs
• SOA Information System SOA Requirements	• SOA Verification and Validation Plan –

Develop a SOA Verification and Validation Plan. Include Orthogonal Array Testing System (OATS), which is a method of deriving a set of test cases. The technique selects combinations of test parameters that minimize the number of test cases and maximize the test coverage. See the discussion of Verification and Validation in Table B-1 (Comparison of Traditional and SOA Software Engineering) in Appendix B (Advanced SOA Delivery Tactics).

13.   Implement/Update SOA Governance Approach

| Inputs	Outputs
• SOA Governance and Management Strategy • SOA Policies (enterprise-level)	• Governance approach • SOA Policies (business area – level)

Implement or update a governance approach for the business area. Decide what parts of the enterprise-level SOA Governance and Management Strategy apply to the business area. Add the additional business area-level detail needed. For example, a business area may need to develop and enforce additional policies.

SOA Life Cycle Methodology

Service Sustainment

Service Sustainment provides the processes to support and maintain SOA in an operations environment. This occurs not only in a steady state environment where an organization has all the support processes and infrastructure in place and is creating services as needed (see Figure 3-16), but in an environment where an organization is on the path to SOA maturation and may be pursuing both a top down and bottom strategy as they adopt SOA. See Appendix B, Advanced SOA Delivery Tactics for a detailed discussion of feature-based development and continuous and concurrent delivery.
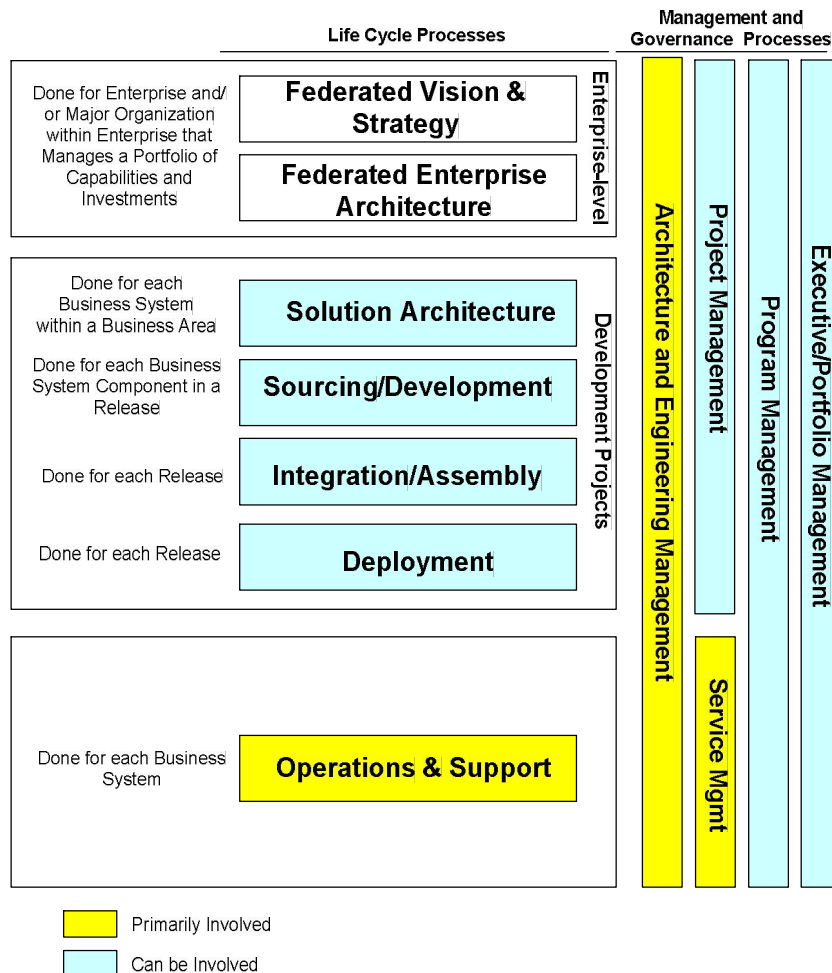
FIGURE 3-16
Service Sustainment Processes

Acquisition Approach

The methodology discussed in the first three chapters is an "engineering" methodology. In the next version of this document, this chapter will cover an acquisition approach to SOA. This adds an "Acquisition Management" layer to the methodology framework as illustrated in the following figure:
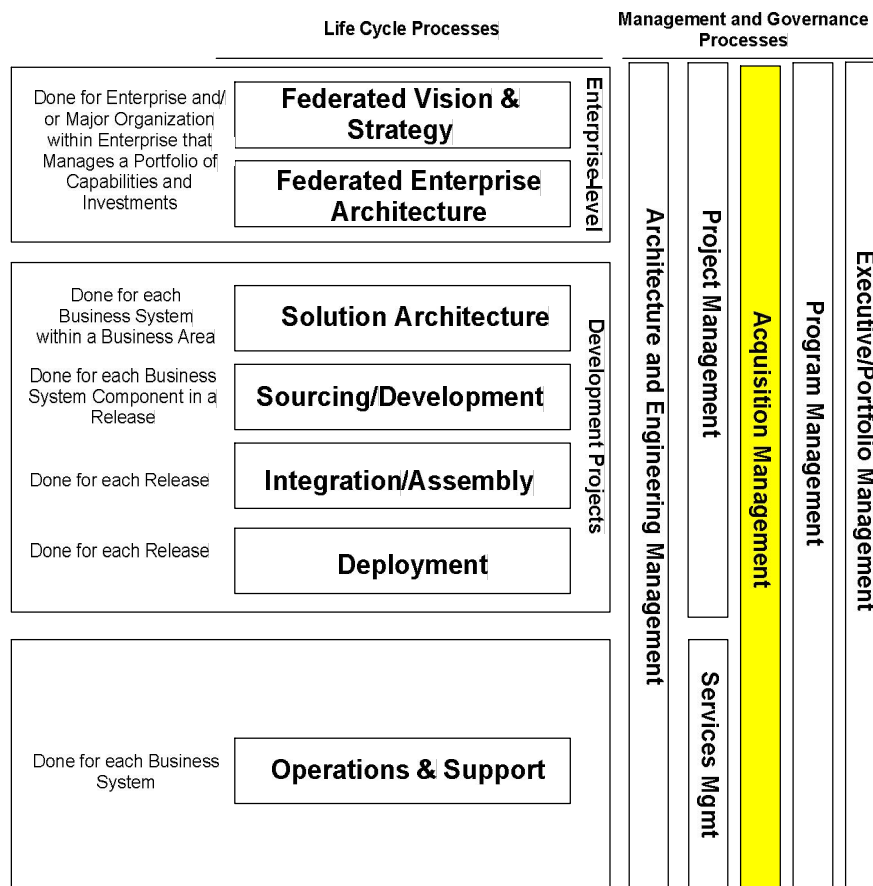
FIGURE 4-1
Acquisition Management

Acronyms

The following is a list of relevant acronyms.

ACT	American Council for Technology
BAA	Business Area Analysis
BEA	Business Enterprise Architecture
BMMP	Business Management Modernization Program
BOE	Basis of Estimate
BPEL	Business Process Execution Language
COE	Center of Excellence
COI	Communities of Interest
C-RUP	Catalyst-RUP
Crystal	Is not an acronym but a word. It is used to label a kind of agile development process.
CSC	Computer Sciences Corporation
DFD	Data Flow Diagram
DISA	Defense Information Systems Agency
DoDAF	Department of Defense Architecture Framework
FDD	Feature-Driven Development
FEA	Federal Enterprise Architecture
FTF	Federal Transition Framework
IC	Intelligence Community
IDL	Interface Definition Language
IOR	Interoperable Object Reference
ITIL	Information Technology Infrastructure Library
MDA	Model Driven Architecture
MODAF	Ministry of [UK] Defence Architecture Framework
MOF	Meta-Object Facility
NCES	Net-centric Enterprise Services
OASIS	Organization for the Advancement of Structured Information Standards
OATS	Orthogonal Array Testing Strategy
OMG	Object Management Group
OO	Object-Oriented
OOAD	Object-Oriented Analysis and Design
OV-6c	DoDAF Operational View 6c - Operational Event-Trace Description
PDP	Policy Decision Point
PEP	Policy Enforcement Point

QoS	Quality of Service
RTM	Requirements Traceability Matrix
RUP	Rational Unified Process
SAML	Security Assertions Markup Language
SAR	Systems Architecture Requirements
SCRUM	Is not an acronym but a word. It is used to label a kind of agile development process.
SDLC	Systems Delivery Life-Cycle
SETA	Systems Engineering and Technical Assistance
SOA	Service-oriented architecture
SOAP	Simple Object Access Protocol
SPRINT	Is not an acronym but a word. A very short iteration of delivery. A part of the SCRUM program management method
STORM	Solution Template and Open-sourced Resource Model
SV-4	DoDAF Systems View 4 - Systems Functionality Description
TPM	Technical Performance Measure
UDDI	Universal Description, Discovery and Integration
UML	Unified Modeling Language
W3C	World Wide Web Consortium
WS-CDL	Web Services Choreography Description Language
WSDL	Web Services Description Language
XACML	XML Access Control Markup Language
XKMS	XML Key Management Specification
XMI	XML Metadata Interchange.
XML	eXtensible Markup Language
XSD	XML Schema Definition
XSTL	eXtensible Style Sheet Language Transformations

References

Allen, Paul. *Service Orientation: Winning Strategies and Best Practices*, Cambridge: Cambridge University Press, 2006.

Bieberstein, Sanjay Bose, Marc Fiammante, Keith Jones, and Rawn Shah. *SOA Compass: Business Value, Planning, and Enterprise Roadmap*, 2006

Erl, Thomas. *Service-Oriented Architecture: Concepts, Technology, Design*, New York: Prentice Hall, 2005.

Erl, Thomas. *Service-Oriented Architecture: A Field Guide to Integrating XML and Web Services*, New York: Prentice Hall, 2004.

Hurwitz, Judith, Robin Bloor, Carol Baroudi, Marcia Kaufman. *Service Oriented Architecture for Dummies,* Hoboken, Wiley Publishing, Inc., 2007.

Krafzig, Dirk, Karl Banke, Dirk Skama. *Enterprise SOA: Service-Oriented Architecture Best Practices*, Upper Saddle River, Prentice Hall Professional Technical Reference, 2005.

Marks, Eric A., Michael Bell, *Service-Oriented Architecture: A Planning and Implementation Guide for Business and Technology*, Hoboken: John Wiley & Sons, Inc., 2006.

McGovern, James, Oliver Sims, Ashish Jain, Mark Little, *Enterprise Service Oriented Architectures: Concepts, Challenges, Recommendations*. Dordrecht: Springer, 2006.

Rodgers, Everett. *Diffusion of Innovations, 4th edition,* New York: The Free Press, 1995.